142
RM/C

FIRM/C14

FAO Fisheries Circular No. 142
(Distribution restricted)

FIRM/C142

LIBRARY
SEP 1 - 1972
FISH & WILDLIFE SERVICE

JAPANESE ECHO-SOUNDING RESEARCH ON SQUID

prepared by

Marine Biology and Environment Branch
Fishery Resources Division
Department of Fisheries

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, May 1972

PREPARATION OF THIS DOCUMENT

As a result of correspondence between Dr. D.F.S. Raitt, Chief, Marine Biology Section, Fishery Resources Division and Dr. K. Shibata (Japan)[1], the latter kindly agreed to translate several important Japanese papers on echo-sounding work being carried out on squid. This is a field in marine acoustics research which is not well documented and it is with pleasure that FAO agreed to circulate these translations, in their original form, for information and comment.

In Japan, squid constitutes one of the most important fisheries and the quantity of common squids, mainly Surume-ika (Ommastrephes sloanei pacificus), landed in 1969 was 570 000 metric tons. More than 2 000 boats are employed and they are detecting squid schools with echo-sounders operated mainly at 30, 50, and 200 kHz.

FAO is undertaking a comprehensive review of the world's marine resources (FAO World Appraisal of Fishery Resources) as part of the Perspective Study of World Agricultural Development (PSWAD) and there is a great interest in developing such relatively unconventional resources as cephalopods. In the overall context of this work these papers are particularly relevant.

1/ Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, Japan 852

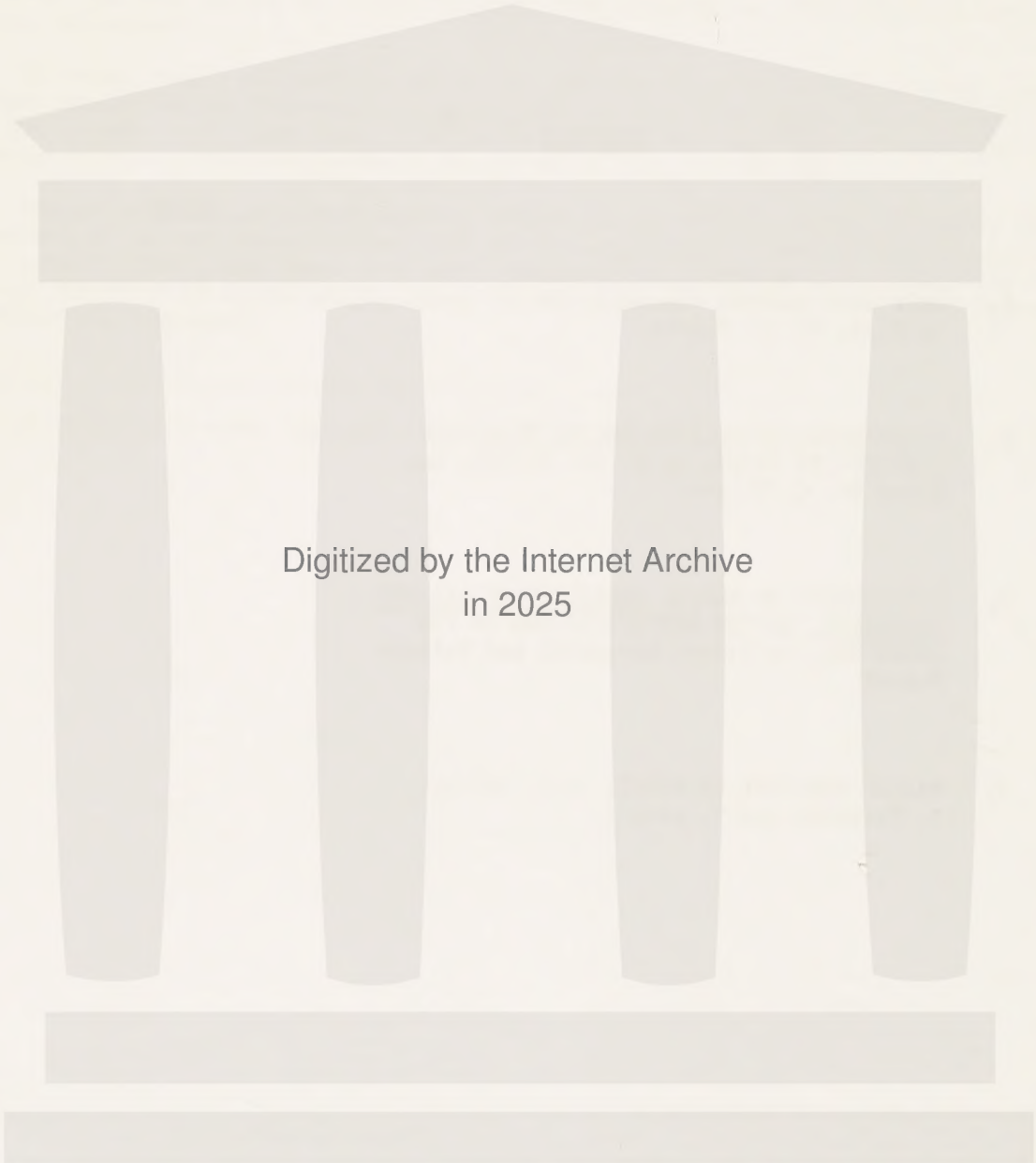
WI/C8927

FAO Fisheries Circular (FAO Fish.Circ.)

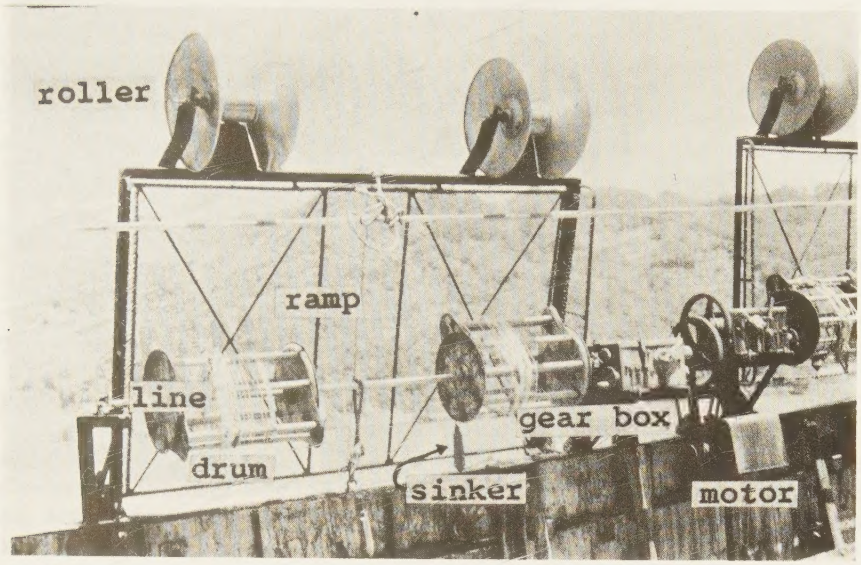
A vehicle for distribution of short or ephemeral notes, lists, etc., including provisional versions of documents to be issued later in other series.

CONTENTS

		Page
1.	HAND LINE FISHING FOR SQUID IN THE JAPAN SEA, by Efren Ed. C. Flores	1
2.	ECHO-TRACES TYPICAL OF SQUIDS IN WATERS SURROUNDING JAPAN, by Keishi Shibata and Efren Ed. C. Flores	7
3.	ECHO-TRACES OF SQUID, OMMASTREPHES SLOANEI PACIFICUS, IN THE CENTRAL WATERS OF THE JAPAN SEA, by Tetsuo Kawaguchi and Tatsuro Mazumi	15
4.	TARGET STRENGTH OF SQUID, by T. Matsui, Y. Teramoto and Y. Kaneko	27


Digitized by the Internet Archive
in 2025

https://archive.org/details/fao-fisheries-and-aquaculture-circular_1972-05_142



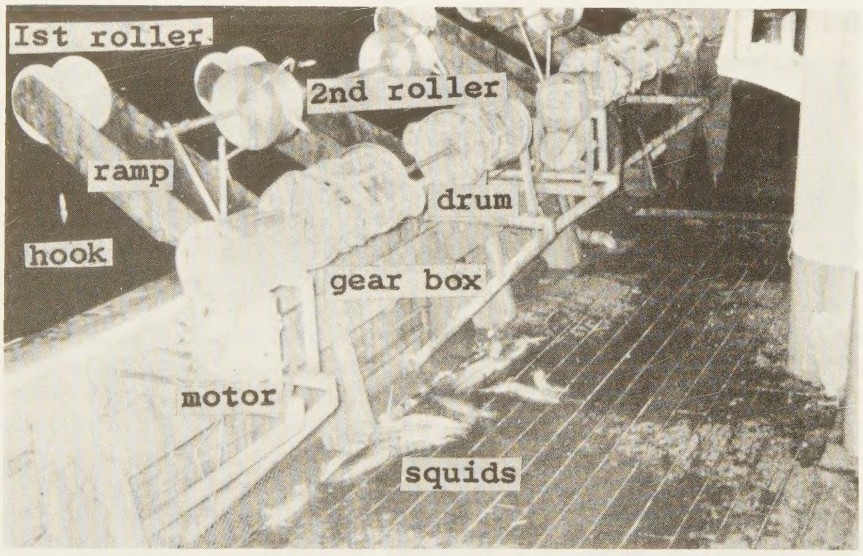


Figure 3. Mechanical squid handline
(A) Frame (B) Steel plate

Figure 4. Squid fishing boat

Figure 5. Unloading of catch at fish landing

HANDLINE FISHING FOR SQUID IN THE JAPAN SEA

by

Efren Ed. C. Flores*

Handline fishing for squid is one of the most important coastal fisheries in Japan. In 1969, for example, 1 200 boats took 50 000 tons[1]. The major ports for this fishery are Sakai-minato City, Tottori Pref.; Hamada City, Shimane Pref.; Kanazawa City, Ishikawa Pref. and Niigata City, Niigata Pref.

The main species caught is Ommastrepes sloanei pacificus locally called "Surume-ika". Others are "Kaka-ika" Sthenotensis bartrami; "Budo-ika" Loligo budo; "Kensaki-ika" Doryteuthis kensaki; "Yari-ika" Doryteuthis bleekeri.

This report deals with the development of the fishing gear and its present operation.

Fishing ground

The squid fishery has gained impetus with the discovery of a new and prolific fishing ground, Yamato-tsui, through the joint efforts of the Prefectural Fisheries Experimental Stations along the Japan Sea in cooperation with the squid fishing operators. This ground is located in the central area of the Japan Sea where the Tsushima Warm Current and the Liman Cold Currents converge. Optimum temperature for squid in the area is between 5° and 15°C.

Fishing gear

Originally the squid handline was a simple pole and line gear consisting of a jig, line, pole and handle as shown in Figure 1[2]. Poles are made of bamboo cane 50 to 60 cm long and are fastened to a wooden handle measuring 30 to 40 cm. The bait then used was a strip of dried squid wrapped around a 7 to 8 cm long horn jig.

The simplicity of the gear limited catches when a large school was attracted by the lamps. The multiple squid handline was then developed to improve catching efficiency. The modified handline consisted of a series of jigs spaced at intervals of about 60 to 80 cm with a total length of 20 to 30 m containing 15 to 20 jigs. Between the series of jigs and the vessel is a leader the length of which is adjusted to keep the jigs within the layer of squid. This concentration layer is determined with the echosounder. To keep the whole gear vertical, a lead sinker is placed at the bottom end of the series of jigs.

The line is made of monofilament nylon the thickness of which varies according to depth. The sinker and jigs at the bottom end of the line are attached to smaller diameter monofilament than those near the surface since the latter receive more strain. The average line diameter is 1 mm.

The jig itself has also changed in design with the addition of a lower ring to allow it to be joined in series as shown in Figure 2. This modification, placing the jigs in series, made handling the lines difficult. To overcome this, a manually operated revolving wooden drum was developed to handle the lines.

---

* On post-graduate course, Faculty of Fisheries, Nagasaki University, Nagasaki, Japan.
Instructor, College of Fisheries, University of the Philippines, Quezon City, Philippines.

With expansion of the fishing operation, bigger boats are now being used and 12 to 15 units are often installed on a vessel. Each unit contains two lines. Since extended fishing time made the operation laborious, an electric motor was fitted onto the drum and coupled to a gear box for better control. The drive for the squid jigging gear is shown in Figure 3, A and B.

Presently two general unit designs are in use. The tilting framed ramp shown in Figure 3A employs one roller and the line drum. The frame is lined with netting. In operation the unit is tilted outboard to a position where the roller is higher than the drum. Consequently, during hauling when the jig is between the two, it is upside down. This permits the squid to slide off the unbarbed hook, down the panel and be collected in buckets at the rail. Figure 3B shows a steel plate type unit. This model uses two rollers constructed of plastic or aluminium in front of the storage drum. When the jig is between the rollers the squid drops to the plate and slides to the deck.

Fishing vessels

The efficiency of fishing with the simple handlines was improved by increasing vessel size to 20-55 gross tons from the earlier 3-5 ton size. Construction was of wood. These vessels were able to employ larger crews operating more lines from a fishing platform built around the rear half of the boat. At present, the boats have increased in size to 50 to 100 tons and are built of steel. Figure 4 shows a 100-ton squid fishing boat with 7 units mounted on each side of the vessel.

The arrangement of the lamps for attracting squid is the same as for the older vessels, the lamps being suspended from a pole or cable stretched between the fore and aft masts. The lights are arranged in this way because it has been observed that squid tend to gather between the bright and dark areas. The hull of the boat produces a suitable shadow area. Total power of the lamps is from 30 to 80 kW.

Fishing operations

Each fishing trip lasts for about a week or ten days at the most. A 100-ton boat with 14 sets of lines has a complement of seven consisting of a captain, an engineer, a radio operator, a cook and three deckhands. The number of deckhands may differ from one boat to another. During actual fishing everyone joins in the operation.

On the fishing grounds echo-searching for squid schools starts at around 1600 h. The determination of squid traces on the echo chart is that of Shibata and Flores[3]. When squid traces appear on the echogram, a marker buoy is dropped on the spot while the boat manoeuvres back. The vessel lays to a sea-anchor from forward and drifts with the current in the same manner as the squid and is able to remain stationary over the school in this way. The lights and echosounder are used continuously through the night in conjunction with the fishing operation. Approaching midnight the catching rate normally increases and the peak fishing is around 0400 to 0500 h, the so-called "Asa-mazume" or morning harvest.

Figure 3B shows the gear in operation with the lines being run out from the drum through the second and first rollers. Running and hauling the line is automatically controlled by the gear box between the drum and the motor. Running speed of the line is made irregular by the somewhat oval shape of the drum. This produces a "jigging" motion to attract the squid.

After passing through the first roller the hooked squid drop on the ramp and slide into the collecting baskets. These baskets are gathered and brought to the fore deck where the squid are cleaned and arranged one layer deep in wooden boxes. The filled boxes are covered with parchment paper and then iced. The paper serves to prevent direct contact between the melting ice and the squid, which would produce discolouration and reduce the market price.

The boxes of iced squid are then stacked in chilled fish-holds but are not frozen. About 400 to 700 boxes compose the average catch per day with each box containing 20 to 25 squids measuring about 18 to 28 cm (mantle length) and weighing 150 to 400 g each.

Fishing takes place all year round. However, there are within-month catch fluctuations with the moon phases. Best conditions exist during dark nights and peak tides. Minimum catches are taken during the full moon period and spring tides. The best season is from September to November.

Disposal of catch

The catch is unloaded at the usual fish landings shown in Figure 5 and is transferred to an assigned broker who gives the selling price. This broker sends the catch to major cities like Osaka, Kobe or Tokyo where another broker is assigned to sell the catch to the retailers. Squid caught during winter are mostly dried and those caught in summer and autumn are marketed fresh.

Acknowledgement

The author greatly appreciates the kindness of Mr. Tetsuo Kawaguchi of the Tottori Prefectural Fisheries Experimental Station for the use of some pictures and also his valuable information. Also thanks to Dr. Keishi Shibata of Nagasaki University for his encouragement and advice.

Expenses for executing this study were partly defrayed by the Japanese Ministry of Education.

References

1/ Japan Fisheries Association, Fisheries of Japan. Tokyo, 45 p. 1971

2/ Japan. Ministry of Agriculture, Fisheries Agency, Illustration of Japanese fishing 1961 boat and fishing gear. Tokyo, 197 p.

3/ Shibata, K. and E.C. Flores. Typical echo traces of squids in surrounding waters of Japan (in press)

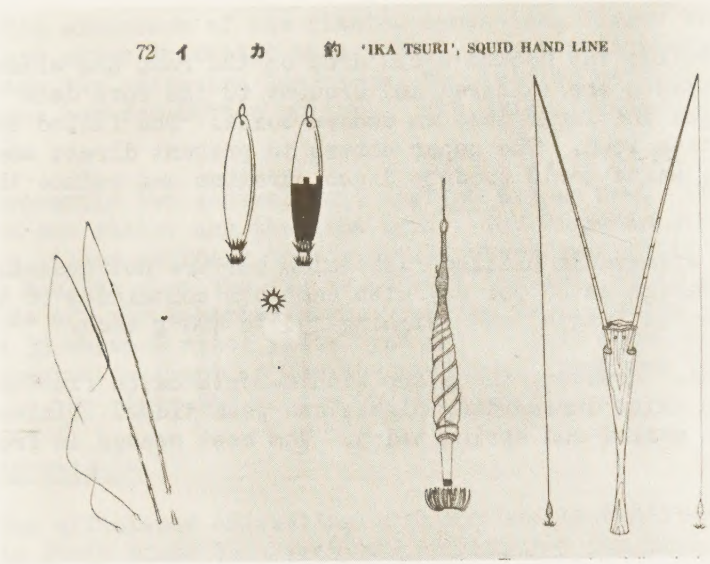


Figure 1. Simple squid handline

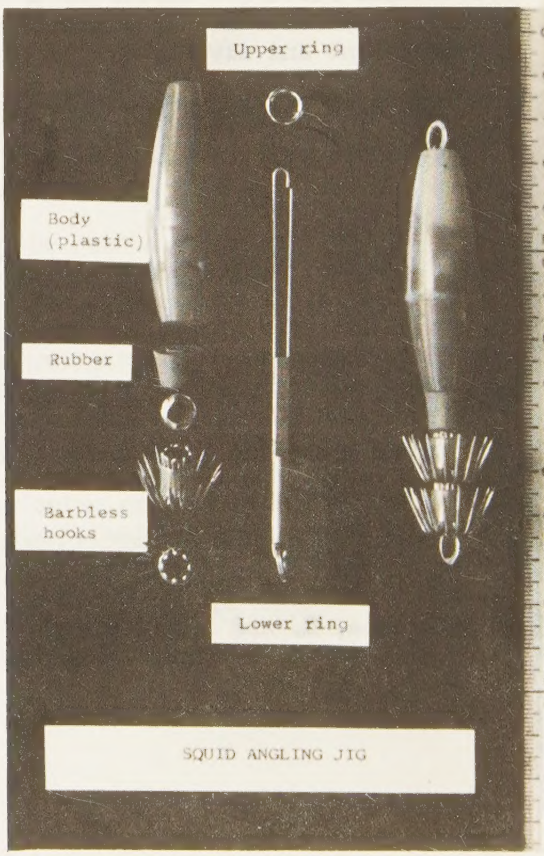


Figure 2. Squid angling jig

ECHO-TRACES TYPICAL OF SQUIDS IN WATERS SURROUNDING JAPAN

by

Keishi Shibata and Efren Ed. C. Flores

Introduction

In the Japanese squid fishery using attracting lights and hand or mechanical lines with 10 to 20 lures per line, the catch varies with seasons and locations both in amount and in species. It includes "Surume-ika" Ommastrephes sloanei pacificus;"Baka-ika" Sthenotensis bartrami; "Budo-ika" Loligo budo;"Kensaki-ika" Doryteuthis kensaki; "Yari-ika" Doryteuthis bleekeri and other species but the dominant species is "Surume-ika". (Surume is the general term for dried squids.)

Recently, the squid fishery has been greatly developed following the exploration of a new rich fishing ground in the Japan Sea, Yamato-tsui, by the Prefectural Fisheries Experimental Stations. This report deals briefly with typical echo-traces of squids at Yamato-tsui which is at about the centre of the Japan Sea where the depth is approximately 300 m.

Echo-traces of squids

Figure 1 shows an example of an echogram obtained on a 200 kHz sounder at the Yamato-tsui squid fishing ground. The squids caught there are probably mid-way in their spawning migration from Hokkaido to Kyushu. The echograms were recorded at about midnight of 12 October 1966 on board the R.V. HYOGO-MARU, 52 GT, of the Hyogo Prefectural Fisheries Experimental Station; when the water temperature at the surface was 21.4°C and the research boat was not underway. The full width of the paper record represents zero to 120 m deep. In this figure, A is the subsurface scattering layer, and small dots are taken to be traces of individual squids, Ommastrephes sloanei pacificus, identified empirically by correlation with test fishing catches. The notched trace as shown in this figure are considered as the typical characteristic squid trace. Normally the most characteristic echo-traces would be obtained by using a high frequency echo-sounder with narrow beam and minimum pulse length, when the boat was stopped.

Figure 2 shows the echo-traces of individual squids in the evening together with the echo-traces of a Secchi disc on the acoustic beam axis for comparison. The range scale of the greater part of the echogram is zero to 120 m deep, but for the part on the left it is 60 to 120 m deep in which the echo-traces of squids are expanded. At that time the squid traces were found between the middle and underside of the subsurface scattering layer. The echo-sounder was operated continuously at a frequency of 200 kHz with a beam angle of 3 degrees to the half power point, and the research boat was not underway but may have been moving at a speed of only a few metres per minute due to wind action; the sea state was smooth.

Let us consider the swimming behaviour of squids from this figure. The echo-recording started on the left hand side and proceeded to the right with the sound beams transmitted perpendicularly from the source. Accordingly, in the traces of individual squids, when they are parallel to the horizon, the squids will have had no speed component in the vertical direction; when the traces are oblique to the horizon the squids' movements will have had vertical components. The traces of A show that the squids moved to deeper water with the boat approaching. From a consideration of the characteristic notched traces of individual squids in Figure 2, we conclude that the swimming speeds and directions of squids' motion vary within a very short period of time. The notched traces must have been caused by complicated motions of squids themselves because the research boat had no heaving motion on the smooth sea at the time of recording.

Figure 3 shows the attracting effect of lamps. The school of squid which swam in the middle or lower part of the scattering layer at a depth of 30–50 m moved up to a depth of 20–30 m or less after the lamps were lit. The rate of change of swimming depth was estimated to be about 1.5 m per minute. The diffusion of the scattering layer at the right side of this figure might also have been caused by the lights.

Figure 4 shows an echogram from a 200 kHz sounder recorded during squid fishing. In this figure, A is the echo-trace of a squid concentration recorded when the boat was underway at a speed of about 6 knots; B is the non-echo period when air bubbles were produced by the boat going astern; all to the right of B was with the fishing boat not underway. Just after point B the attracting lamps were lit and the squid fishing commenced. C indicates the echo-traces of squid schools. Traces of individual squid were also found near the underside of the subsurface scattering layer. D indicates the echo-traces of handlines which were moved actively up and down from the side rail of the boat. It could be seen that the end of the line with artificial lures reached a depth of about 80 m and so their depth range included the whole vertical distribution of the squids. Between E and F was the peak period of fishing when about 3 tons of squids were caught. G indicates individual squid at depths of 80–100 m or more.

Figure 5 shows a series of echograms from a 50 kHz sounder, taken at the peak of fishing in the coastal waters of Toyama Bay. In this figure the full width of the record represents zero to 200 m and the depth of sea-bed at about 100–130 m. The squid traces are scattered from the surface to the sea floor; the continuous traces near the sea floor were not identified as either squid concentrations or fish schools, although traces show that a lot of handlines operated through the full distance between the surface and the sea floor.

Figure 6 is an interesting echo-trace of densely concentrated squids. The echogram was obtained on a 50 kHz echo-sounder in the waters off Rausu at the eastern end of Hokkaido, on board the fishing boat EIKO-MARU in October 1965. About 2 tons of squid were caught here by the one boat.

Figure 7 shows the echogram from a sonar (upper part) in comparison with a simultaneous echogram from a vertical echo-sounder at the same 28 kHz frequency (lower part) when the fishing boat KAIFO-MARU No. 7 was travelling at a speed of about 8 knots in the daytime. These two echograms have been synchronized in time with each other, although the paper speeds differed slightly. The range scale of the record width is zero to 400 m in the upper part and zero to 100 m deep in the lower part.

The clumped dotted traces in the middle of the vertical sounder record were probably concentrations of squids. The echo-traces from the sonar corresponding in time to the clumped squid traces on the vertical echo-sounder show that the maximum detectable range of squid schools for this sonar is about 200–400 m; the echoes from squid schools are much less strong than those from the air bubbles in the wake of a vessel (W).

Experimental observations in Tsushima Strait

A series of experimental observations associated with the identification of squid traces were carried out in the waters off the eastern coast of Tsushima on board the R. V. TSURU-MARU of the Nagasaki Prefectural Fisheries Experimental Station (17–19 December 1965) on the fishing boat of the Nishidomari Fisheries Cooperative Association (20 December) and on the squid-fishing boat CHOSEI-MARU No. 3 (18–22 October 1966

The target strengths of individual squids were measured at 50 kHz and 200 kHz in 1965. These, at 50 kHz were found to be -40 dB for squid with a mantle length of 36 cm and -42–43 dB for squid with a mantle length of 26 cm; the values at 200 kHz were found to be nearly the same. However, the target strength measurement should be done again more accurately in an indoor tank. It is suggested that, following this result, the source level of a 50 kHz

echo-sounder should be more than 130 dB relative to a sound pressure with reference to minimum recordable signal.

For purposes of identifying squid traces a series of observations was made using 50 kHz and 200 kHz echo-sounders, an underwater photo-cell and an underwater television camera on board the fishing boat CHOSEI-MARU No. 3 (20 GT, wooden hull). The boat left Izuhara at 16.30 h, 18 October, arrived at the fishing ground with a depth of 110 m, 40 minutes after sunset, commenced fishing by lines with a sea-anchor out, and continued through the night. About 6 000 squids were caught by five handlines and eight mechanically driven lines with 22 lures per line.

The observations by an underwater TV camera were started at 20.55 h when the camera, looking horizontally, was hung over the side to a depth of 10 m. The actively moved lures were found to be bright only at the hook part. A squid (Ommastrephes sloanei pacificus) followed the lure moving to the surface of the water at a very high speed and suddenly turned to dive. The speed of the squid at the time was estimated from the visual range of the TV camera in water to be 2.5 m per second. The position of a squid when caught by hook was with the mantle part down, with some legs twisted around the hook and with other legs spread in all directions.

The catching of squids commenced about 3 minutes after lighting the lamps, reached a peak, and, after several minutes, decreased gradually. Such a trend of catching with time shows that the reactions of squids to moving lures decreased as time elapsed.

Thus, by using both underwater TV and echo-sounders the behaviour of squids during fishing operations can be observed and echo-traces can be identified as squid traces.

Acknowledgement and Summary

The authors greatly appreciate the kindness of the operators of the above-mentioned fishing vessels for permission to use many echograms in this report. They express their gratitude to the members of Furuno Electric Co. for giving valuable echograms and also their thanks to Mr. T. Kawaguchi of the Tottori Prefectural Fisheries Experimental Station for his valuable advice.

The present paper deals with the typical echo-traces of squid appearing on sonar and on a vertical echo-sounder. Means of verifying that the traces are of squid are examined. Behaviour of squid in the fishery is studied by echo-sounders and by underwater television.

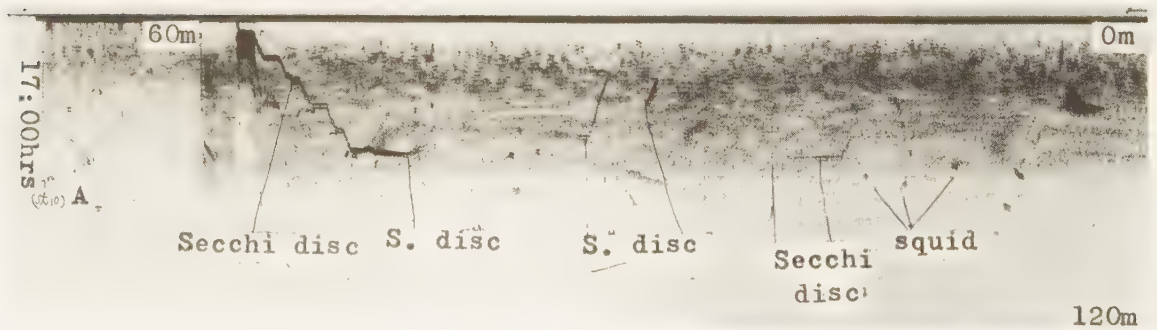
Reference

Shibata, K., 1967 Echo survey on squid fishing ground off Tsushima. Report of the Working Group for estimating fish stocks by acoustic method. Japan Marine Resources Protection Association, Vol. 3:28-34 (in Japanese)

F—863—D 200KC
いかの記録 水深 0～120m
日本海 大和堆 兵庫県調査船 兵庫丸 (52トン)

P2042

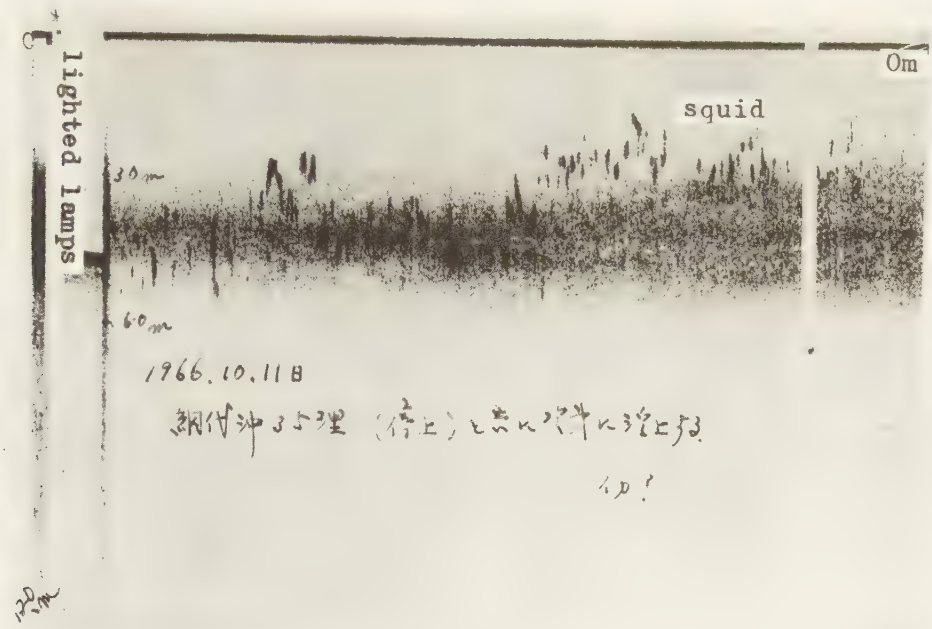
Figure 1. Echogram from the squid-fishing ground Yamato-Tsui at about midnight from a stationary boat R.V. HYOGO-MARU using a 200 kHz sounder. These are echo-traces of individual squids (Ommastrephes sloanei pacificus) and A is the subsurface scattering layer



F—863 - D 200KC
いかの記録 水深 0～120m
日本海 大和堆 兵庫県調査船 兵庫丸 (52トン)

P2041

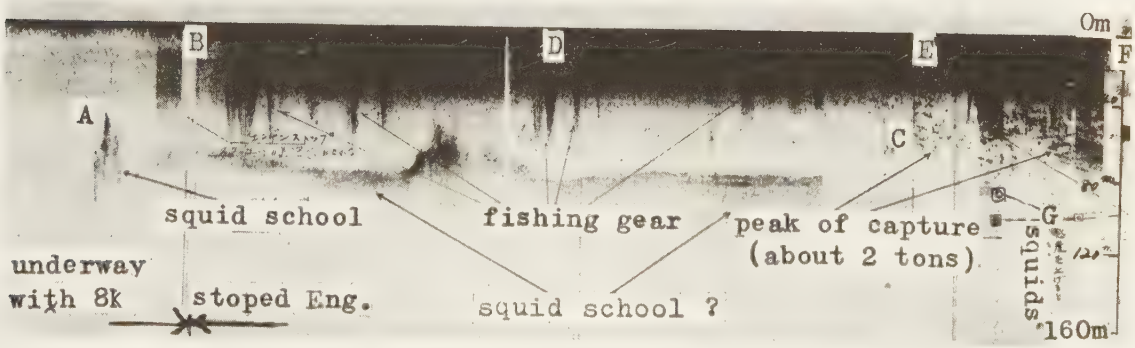
Figure 2. Typical echo-trace of individual squids from a 200 kHz sounder on a stationary boat, showing swimming behaviour



F—863—D 200KC
いかの記録 水深 0～120m
日本海 大和堆 兵庫県調査船 兵庫丸 (52トン)

P2038

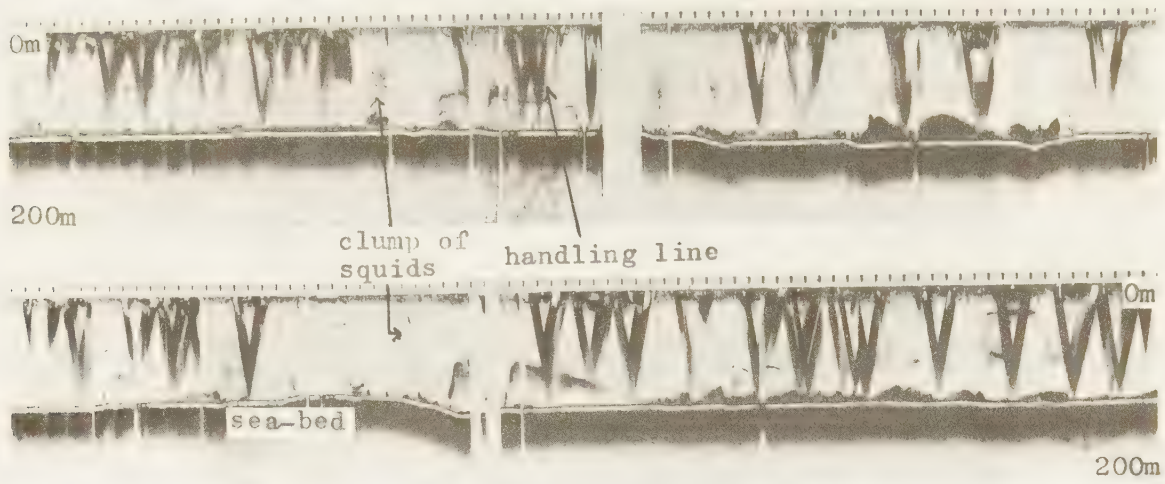
Figure 3. Changes of swimming layer of squids lured to attracting light (200 kHz sounder)



F—863D型 200KC イカの記録 佐渡沖 第一美濃部丸 S.41.6

P2259

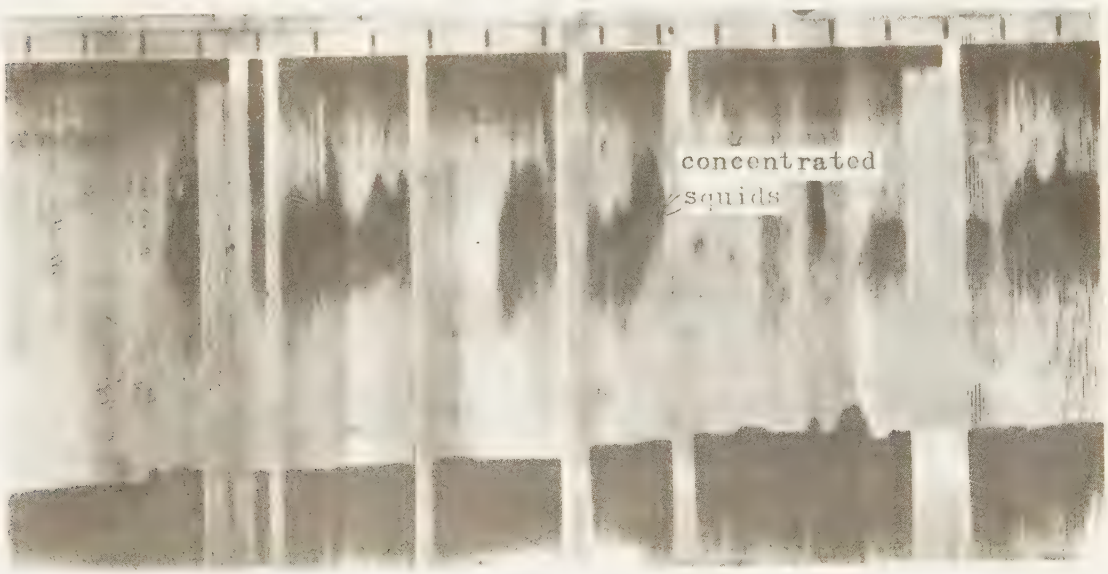
Figure 4. Echo-traces of concentrated squids, individual squids and handlines moving actively up and down at the peak of fishing in the waters off Sado in Japan Sea, from a 200 kHz sounder The left side of the chart is from a boat under way and the right side from a stationary boat



F—830特型 50KC強力 イカ釣
0～200m 富 山 湾 航側パイプ9R

P2267

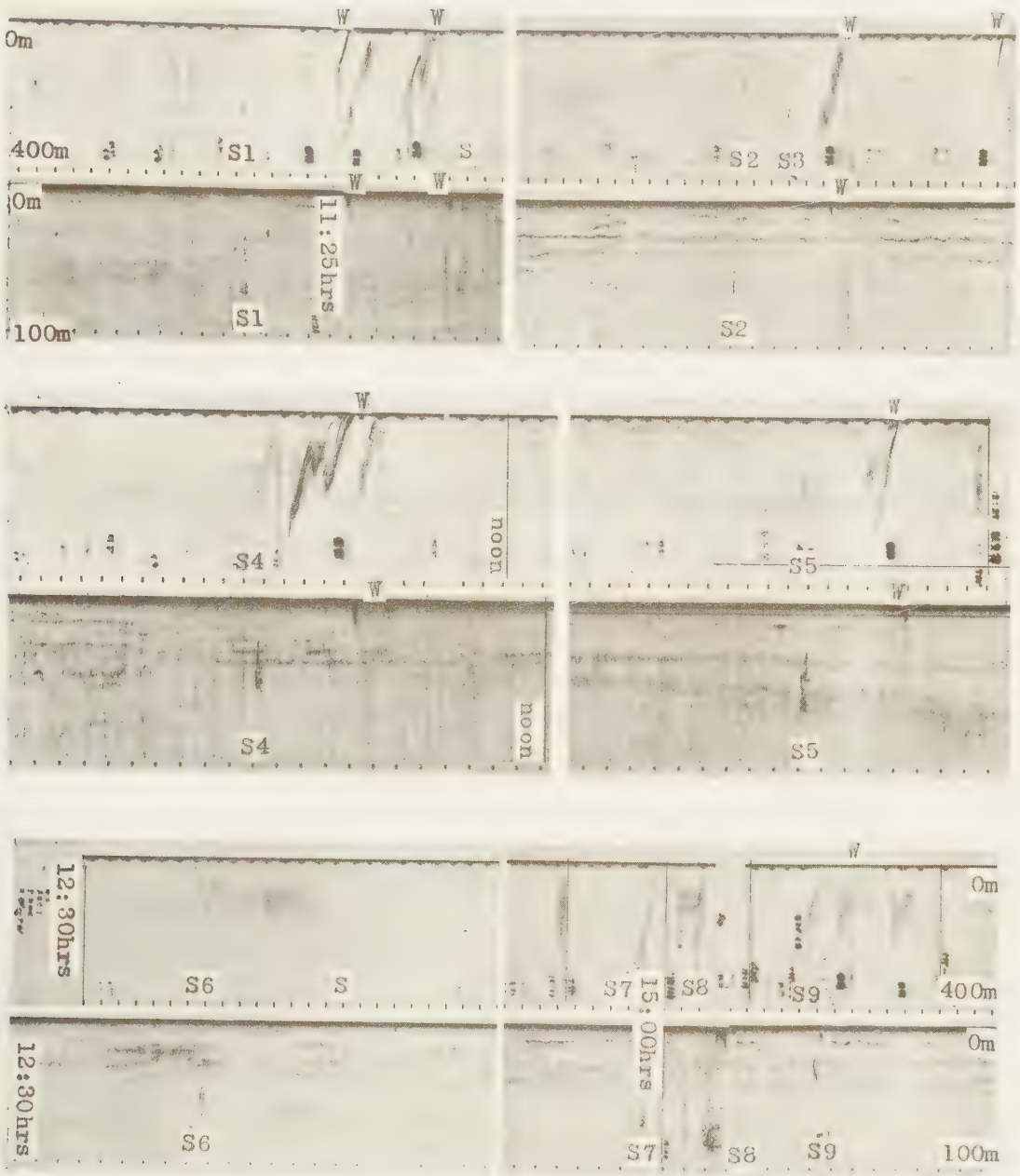
Figure 5. Echo-traces of fishing gear, individual squid and concentrations of squids from a 50 kHz sounder The thick traces near the bottom were unidentified



昭和39年10月
F 830 B 型 50KC
雛 臼 沖 イカ魚群
函 館 市 栄 幸 丸

P 1046

Figure 6. Densely concentrated squids in the waters off Rausu (50 kHz sounder)



S46.7.24 第7海光丸（94トン）
上側
ソーナーFH-102によるイカの記録
日本海北西部（40°N, 132°E）
レンジ 400m
ティルト 75°～80°
ゲイ 〃
AGC 1
パルス巾 2 m s
左舷40°～右舷40°首振探索

下側
ソーナーの記録を追尾して魚群探知機
FHG-3000Sに現われたイカの記録
レンジ100m

Photo No. 5471

Figure 7. Echo-traces of concentrated squids in the northwestern waters of Japan Sea, 40°N, 132°E, obtained on board the fishing boat, KAIKO-MARU No. 1, 94 GT

Upper part: 28 kHz sonar (pulse length: 2 m sec.; range: 0 to 400 m; tilt angle: 75° to 80°; scanning: auto-scanning between 40° on either side)

ECHO-TRACES OF SQUID, *Ommastrephes sloanei pacificus*, IN THE CENTRAL WATERS OF JAPAN SEA

by

Tetsuo Kawaguchi[1/] and Tatsuro Nazumi[2/]

Introduction

The exploratory project on fishing grounds in the central waters of Japan Sea started in 1961. It included an echo-survey of squid concentrations. However, distinct echo-traces of squid could not be obtained at first, because the detection range of echo-sounders for squid was very short and also the squid traces could not be distinguished from other traces. Since 1966, the squid traces could be identifiable by using highly efficient echo-sounders. These sounders have been installed on the research boats of various Fisheries Experimental Stations. In 1968 and 1969, studies on the distribution of squid and squid fishing grounds in off-shore waters of the Japan Sea were organized between the Japan Sea Regional Fisheries Research Laboratory of the Fisheries Agency and twelve Prefectural Fisheries Experimental Stations along the Japan Sea coast.

This report deals with some results of the echo-survey of squid fishing grounds in this programme.

Materials and method

The echograms for detecting squids taken both during the day and at night time from a running boat and only at night from a stationary boat actually fishing, were analysed with a view to identifying the echo-traces of squid.

The research boats that took part in this survey were R.V. TOTTORI-MARU No. 1 (99 GT) of the Tottori Prefectural Fisheries Experimental Station and R.V. SHINTAJIMA-MARU (119 GT) of the Hyogo Prefectural Fisheries Experimental Station. The echo-sounders used in this survey were as in Table 1.

Table 1 Specifications of echo-sounder

Name of boat	Type	Recording range (m)	Beam width between half power points	Paper
TOTTORI-MARU No. 1	BI-500	0 to 400 0 to 800	26° & 34° at 50 kHz 7.6° at 200 kHz	Moist 15 cm wide
TOTTORI-MARU No. 1	TL-16	0 to 200 0 to 400 0 to 1 600	22° at 28 kHz 10° at 75 kHz 6° at 200 kHz	Moist 15 cm wide
SHINTAJIMA-MARU	F-812WAD -1	0 to 400 0 to 2 000	60° at 14 kHz 6° at 200 kHz	Moist 15 cm wide

1/ The Sakai Branch of Tottori Prefectural Fisheries Experimental Station, Sakae-Machi, Sakaiminato-Shi, Tottori-Ken, 684

2/ The Kasumi Branch of Hyogo Prefectural Fisheries Experimental Station, Kasumi, Kasumi-Machi, Kinosaki-Gun, Hyogo-Ken, 669-65

Consideration

The identifications of echo-traces can be made empirically by correlation of traces with the catch and experimentally by direct visual observations by a diver and underwater TV camera. The measurements of target strengths of fishes, in association with biological observations on environment and ecologs and especially on schooling behaviour, can also be helpful in the indirect identification of fish species.

The problems of identifying echo-traces of squid, Ommastrephes sloanei pacificus, are being tackled by many workers. Mishima[1] reported on the echo-traces of concentrated squids from a 14 kHz sounder in a fishing boat operating hand lines and the relation between echo-traces and composition of catch. Shibata[2] reported fundamental acoustic measurements and experimental observations of squid schools by means of an underwater TV camera and a hydrophone during fishing in the coastal waters of Tsushima. Both of these reports were only on the echo-traces of squids attracted around the light from a stationary boat while fishing; squid traces could not be identified from a running boat.

At the "Interim Scientific Meeting on the Fluctuation of Marine Resources for Developing the Accurate Prediction of Squid Capture", 1968, Kawaguchi reported on the behaviour of squids as seen on echograms during fishing at night and from a running boat in the day time, and Nazumi demonstrated the changes of swimming depths of squids relative to the marine environmental conditions; Hayashi spoke about squid swimming depth, optimum temperature and stock size estimated by an acoustic method.

Fishes that gave traces on an echogram from the central waters of Japan Sea were the summer juveniles such as anchovies, jack mackerels, common mackerels, etc., in the water mass of the Tsushima Warm Current System. Included in the echogram were plankton traces from such cold water species as Themisto japonica, Euphausia pacifica, Calanus plumchrus, etc.

1. Echo-traces of squids from a running boat

The classification of echo-traces of squids was made in relation to the environmental factors such as the vertical distribution of water temperature and the swimming depth of the squid. Then the echo-traces of squids were identified empirically by a correlation with catch, and by visual observations near the attracting lights together with collection of samples by nets.

Figure 1 shows typical echo-traces of squids in the day time from a running boat with a speed of about 8 knots in off-shore waters of the Japan Sea. The upper part in this figure (A) shows an echogram from a 200 kHz sounder. In this the echo-traces appearing just below the surface reverberation are schools of anchovies, the thin line about 30 m deep is the sub-surface scattering layer and the clumps of dotted small traces at 50 to 90 m deep are the squid schools. Such squid schools are seen at 60 to 100 m or more in the middle part of this figure (B) in which they are arrowed. Also in echogram B is a group of squid traces (a) which the boat returned to and ran over again at reduced speed (b). The bottom part of Figure 1 shows an echogram from a 75 kHz sounder. In this, scattered traces at about 10 m depth are schools of anchovies and clumps of traces shown by the arrow are the squid schools.

Figure 2 shows diagrammatically the vertical distribution of fishes and the water temperature in the central waters of the Japan Sea. In this figure time is on the X-axis and the depth of water is on the Y-axis. The 3, 4, 5, 10 and 20°C isotherm lines are shown and the vertical solid lines indicate the range of swimming depths of squids.

Figure 3 shows a relationship in the day time between the depth of fish traces and water temperature. Echo-traces recorded on the fishing grounds, were generally separable into three categories: squids, juvenile fishes and scattering layers. The squid traces were recorded at 75 to 200 kHz in the day time from a running boat, as a clump of dotted traces in the intermediate layer 30-100 m deep with a water temperature of 3°-15°C.

The authors concluded that such traces were of squids for the following reasons: i) such traces were regularly found on the rich fishing grounds, ii) large numbers of squids were caught when the lures hung at the same level as the traces and iii) the traces were distributed over a greater range of water temperature than those of any other fishes.

The squids were scattered as individuals or smaller schools in the night time when their depth distribution changed to shallower layers 20 to 50 m deep. The identification of squid traces in the night time became difficult.

The summer juvenile fishes in the water mass of Tsushima Warm Current System appeared in small schools from surface to 15 m depth with water temperature 15° to 25°C; traces of these juvenile fishes were cloudy and in dense layers or patches.

The subsurface scattering layers were found at depths of 20 to 40 m on the boundary layer between the surface water of Tsushima Current and the intermediate water of the Japan Sea proper. The scattering layer in this area is associated with the concentration of Themisto japonica, Euphausia pacifica, Calanus plumchrus, etc. A characteristic of this trace is that its depth varies diurnally.

2. Echo-traces of squids around attracting lights

The large type of fishing boat in the off-shore waters of the Japan Sea fish in the night time using 12 to 15 sets of mechanically driven lines, attracting lamps of 30 to 50 kW, and a parachute-type sea anchor.

Figure 4 shows an echogram from a 75 kHz sounder recorded between 16.30 and 17.30 h on 28 July 1969, when R.V. TOTTORI-MARU No. 1 was operating her fishing gear. A dense concentration of squids was detected at 16.30 h and preparations for fishing were started with the echo-sounder operating continuously. The fishing operation was started at 17.10 h and 0.3 ton of squids was caught in about 20 minutes, the school of squids rising in the water to a level 20 to 30 m deep. In this figure, the dense V-shaped echo-traces are of hand lines with lures which were moving regularly up and down, and the squid schools appear as small patches or dotted traces.

Figure 5 shows echograms recorded in the night time from a boat which was working. A dense squid school was detected at a depth of 40 to 60 m and the fishing operation was started at 17.40 h when the squids, attracted by light and lures, swam up to the 0-30 m depth layer where catching was continuous. From 19.00 to 21.00 h, the squid concentration was scattered away and they swam at 0 to 60 m deep. However, from 02.00 h to 04.30 h, when the majority of the squids swam back to the 0-30 m depth layer, catching was again continuous.

The above observations enabled the authors to improve the identification of echo-traces of squids from a boat operating at night and also in day time.

3. Frequencies of echo-sounders used in squid fishing

The echo-sounders installed on the squid fishing boats operated at frequencies of 28, 50, 75 and 200 kHz, with the majority being at 200 kHz. The shapes of echo-traces of squids vary with the beam widths and sound frequencies as shown in Figure 6.

Conclusion and summary

From an analysis of the echograms taken at the squid-fishing grounds in the central waters of the Japan Sea, the following results were obtained:

1) The squids could be recorded through the day on the echo-sounder paper as distinct echo-traces whether the boat was running or stationary.

2) On the echogram from a running boat, the squids were recorded as clumps of dotted traces or sharp comet-shaped traces in the day time, but as scattered very small dots 30-100 m deep in the night time.

3) On the echogram from a fishing boat in operation, the squid traces were found in 0 to 60 depth as dotted traces around the traces of fishing gear, and dense concentrations of squids were recorded as patches.

4) The optimum sounder characteristics for the purpose of squid detection were considered to be frequency 75-200 kHz, narrow beams, and minimum pulse length.

References

1/ Mishima, S., Detection of squid schools by echo-sounder, Bull.Fac.Fish Hokkaido Univ., 1951 1-2: 99-100 (in Japanese)

2/ Shibata, K., Echo survey on squid fishing ground off Tsushima: Report of the Working 1967 Group for estimating fish stocks by acoustic methods. Japan Marine Resources Protection Association, Vol. 3: 28-34 (in Japanese)

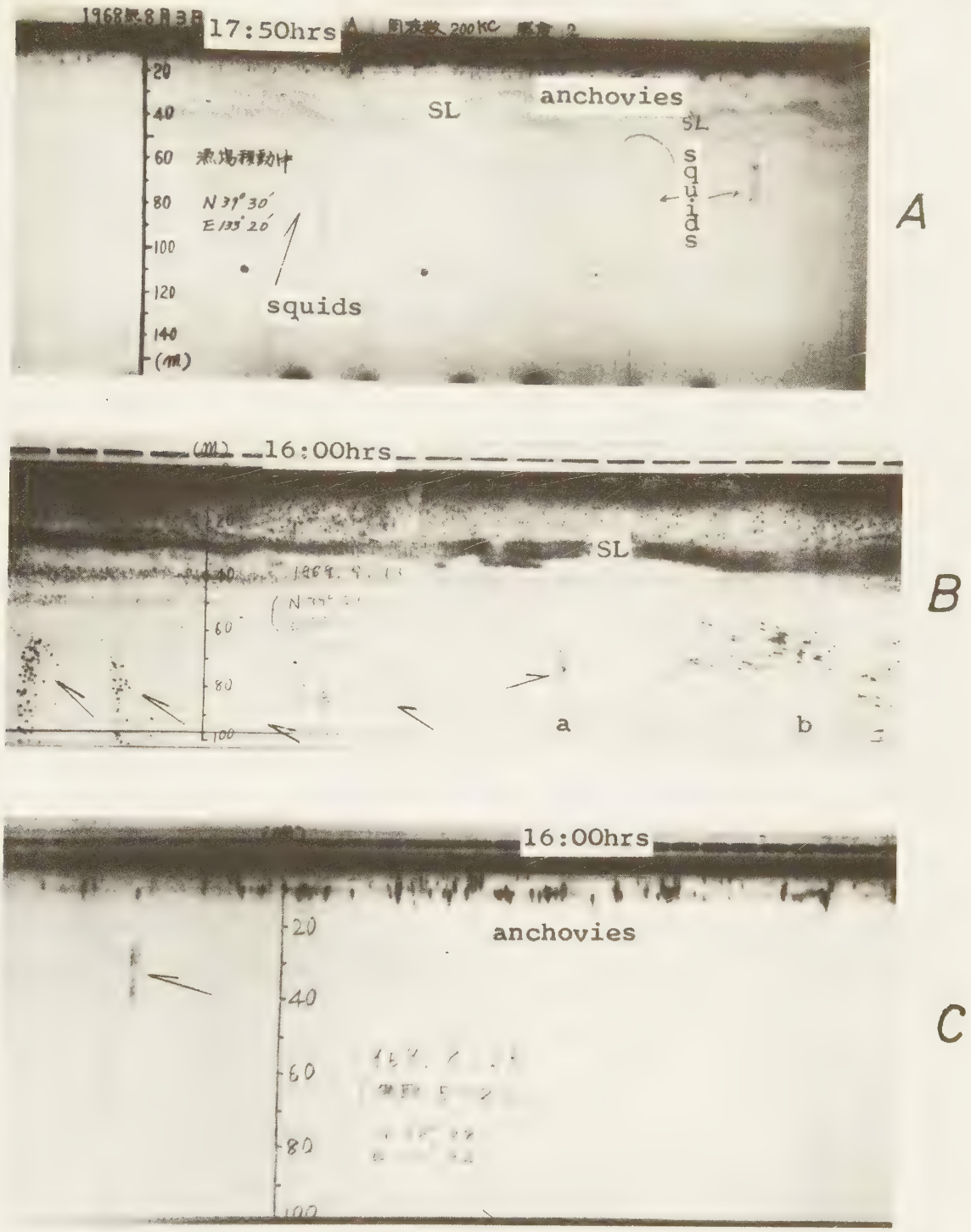


Figure 1. Echo-traces of fishes in the day time from a running boat in the central waters of Japan Sea

	Echo-sounder		Date	Location
A	B1500	200kHz	3 Aug. 1968	39.5°N 133.3°E
B	TL16	200kHz	13 Sept. 1968	39.3°N 133.3°E
C	TL16	75kHz	25 Aug. 1968	38.6°N 132.5°E

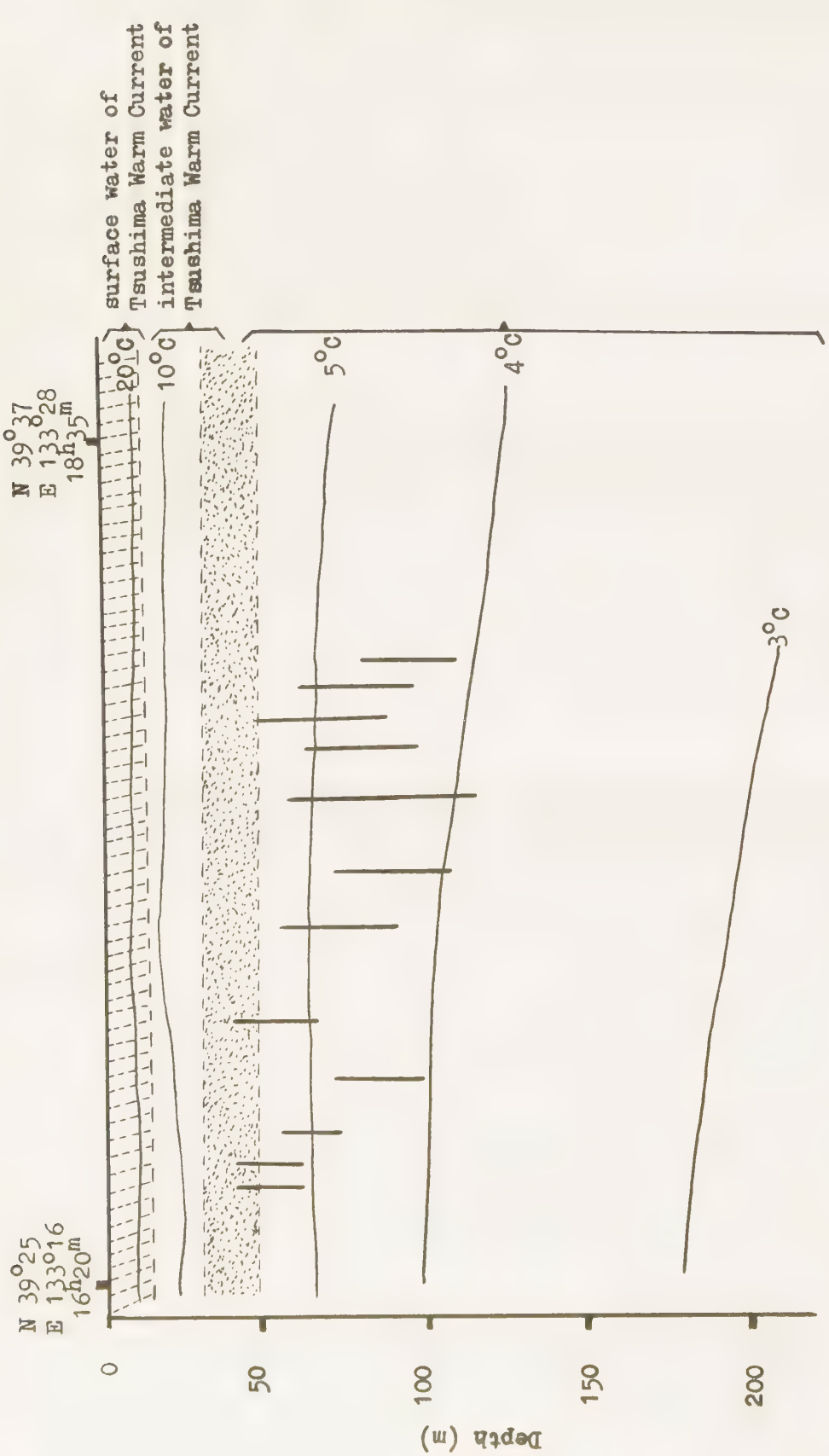


Figure 2. Schematic diagram of squid distribution on fishing grounds

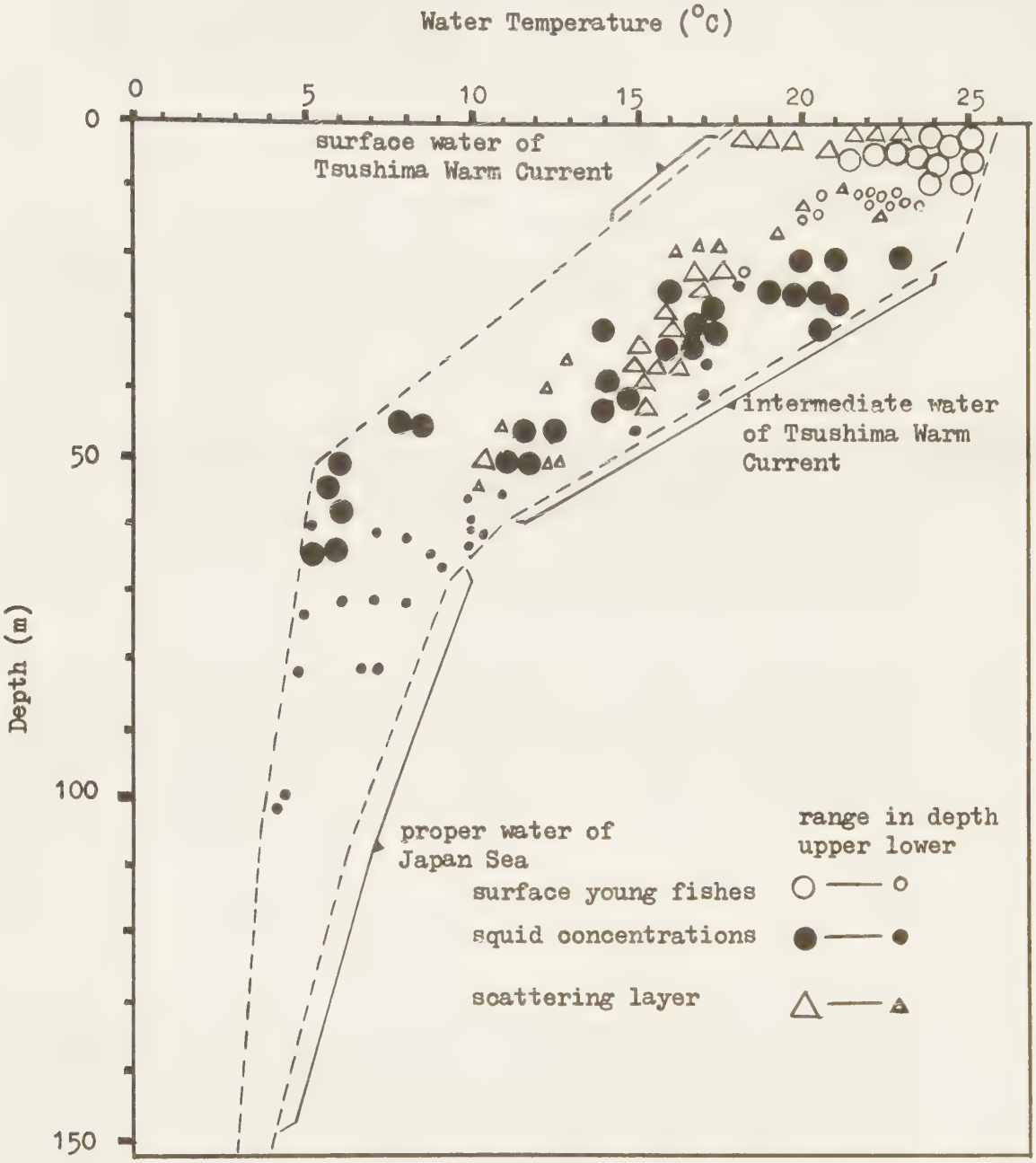


Figure 3. Relationship of swimming layers of fishes to depth and water temperature, from echograms taken in the day time in the central waters of the Japan Sea

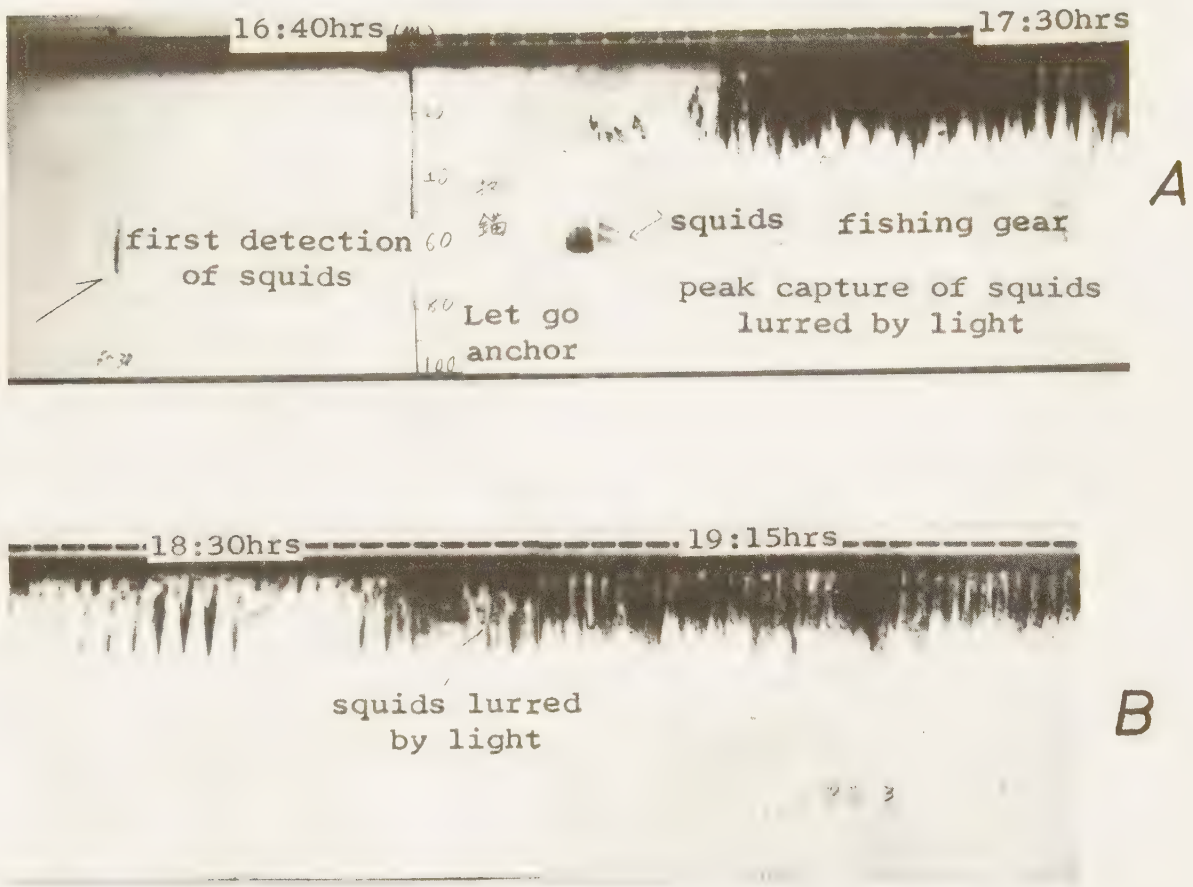


Figure 4. Echo-traces of squids and fishing gears in operation, taken from a stationary boat in the day time between 16.30 h and 10.30 h, 28 July 1969 at 39.5°N, 133.8°E (TL16, 75 kHz)

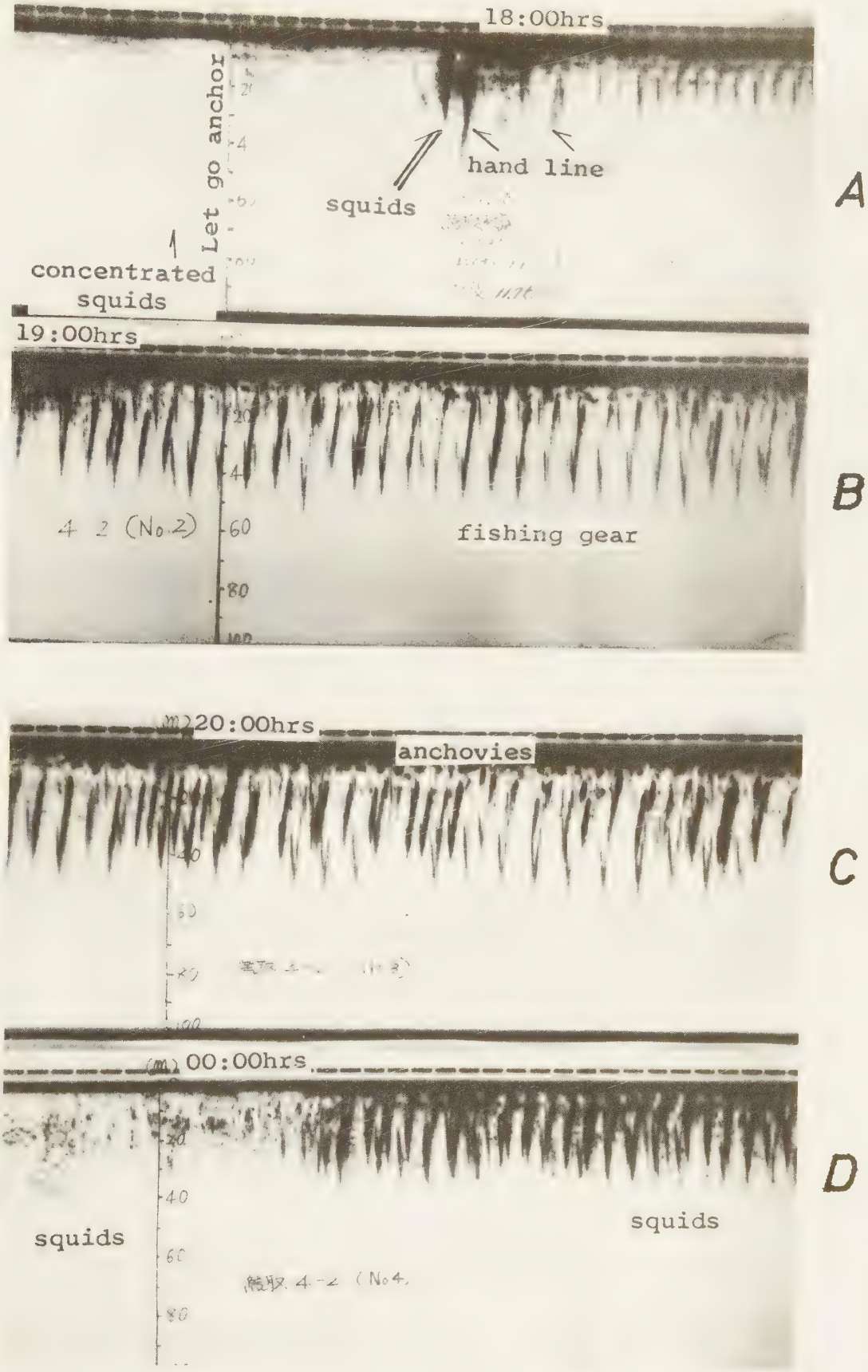


Figure 5 - 1. Echo-traces of squids, by T. Kawaguchi and T.Nazumi

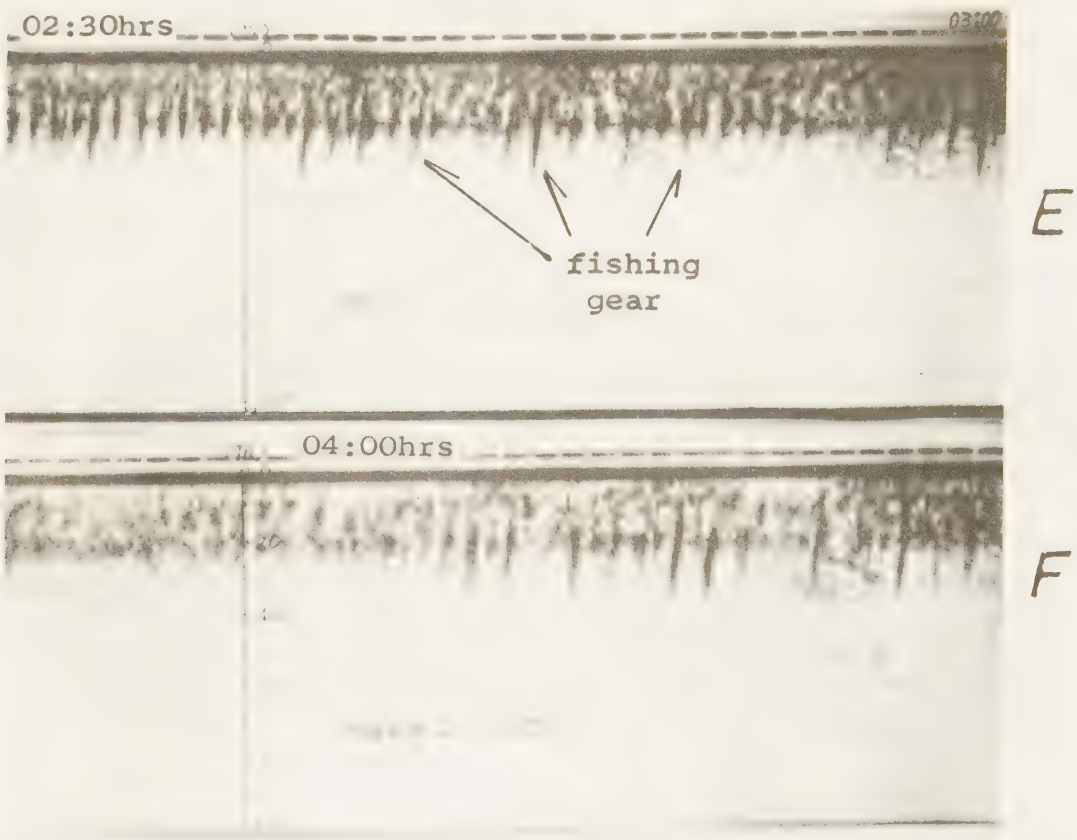
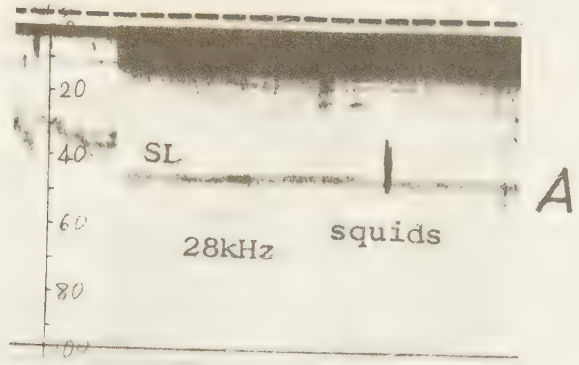
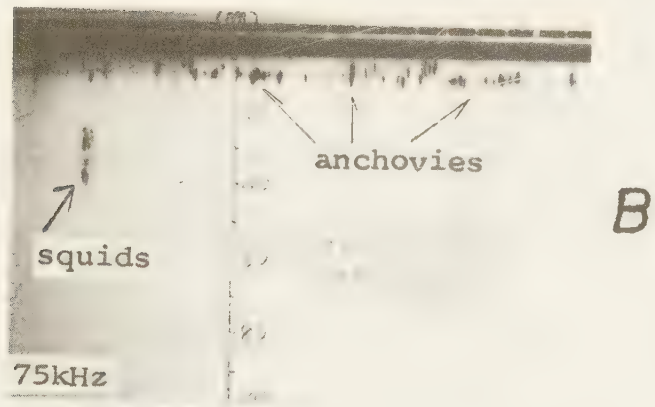


Figure 5 - 2. Echograms from a 75 kHz sounder recorded at night while squid fishing from 14.40 h, 8 Aug. to 04.30 h, 9 Aug. 1969, when about 3.5 tons of squids were caught





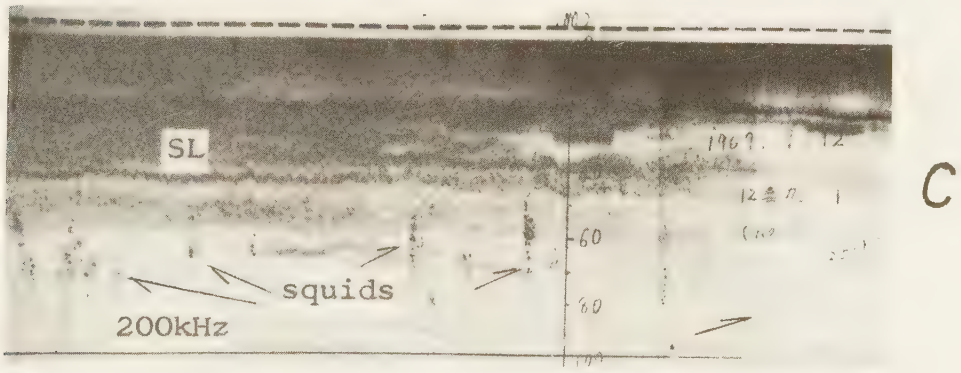


Figure 6. Echo-traces of squid schools recorded on sounders at different frequencies while the boat was running

TARGET STRENGTH OF SQUID

by

T. Matsui,[1/] Y. Teramoto[1/] and Y. Kaneko[1/]

Knowledge of the acoustic target strengths of squids is one of the reliable keys for determining the size and species of fish detected by echo-sounder. A series of acoustic measurements using the scale model method has been carried out at 50 kHz and 200 kHz operating frequencies in an indoor tank of 1.5 m^3 in the laboratory of the Fisheries Experimental Station, Faculty of Fisheries, Nagasaki University.

The tank was filled with sea water of 1.024 specific gravity and temperature 22°-25°C. The targets used for the preliminary measurements were dead squids of Loligo spp., which had a similar body proportion to common squid, Ommastrephes sloanei pacificus; their size was 11-12 cm mantle length. Measurements were made on eleven squids.

The transmitting and receiving transducers were fixed inside the tank, at about the middle of a side-wall. They were in contact with each other and arranged so as to transmit the ultrasound horizontally. The radii of the iso-level of echo from the standard target was 31 cm at -3 dB for both frequencies. The target was supported on the acoustic axis at a distance of 85 cm from the sound source where the background noise level was minimal. As the target squid was suspended with its body axis horizontally and was rotated around this axis, the incident direction of sonic wave against the target was similar to that for a swimming squid in a field survey with a vertical echo-sounder.

The echo level from a target was calibrated in terms of the level of signal received directly by the receiving transducer when it had been moved and fixed at the target position of 85 cm from the sound source and on the axis of the acoustic beam.

The polar diagram of acoustic back-scattering strength from a squid is shown in Figure 1. In this figure, the scale shows the amplitude relative to the echo amplitude from a ping-pong ball (Ts = -41 dB) at the target position. The maximum echo from a squid was obtained in the dorso-ventral direction of the roll plane. The maximum target strength of a squid of 12 cm mantle length was about-45 dB at 50 kHz and-42 dB at 200 kHz frequencies. The changes of target strengths with body size could not be determined, since the size range of targets was very narrow.

The acoustic polar diagram of back-scattering strength from a jack mackerel, Trachurus japonicus, of 12 cm total length is shown in Figure 2. From comparison of the two polar diagrams which were taken around the long axis of the animals' bodies, the conclusions are as follows:

1) Target strength: squid<fish
2) Number of lobes: squid>fish
3) Fluctuation of echo strength through the polar diagram: squid>fish

1/ Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo-machi, Nagasaki, Japan 852

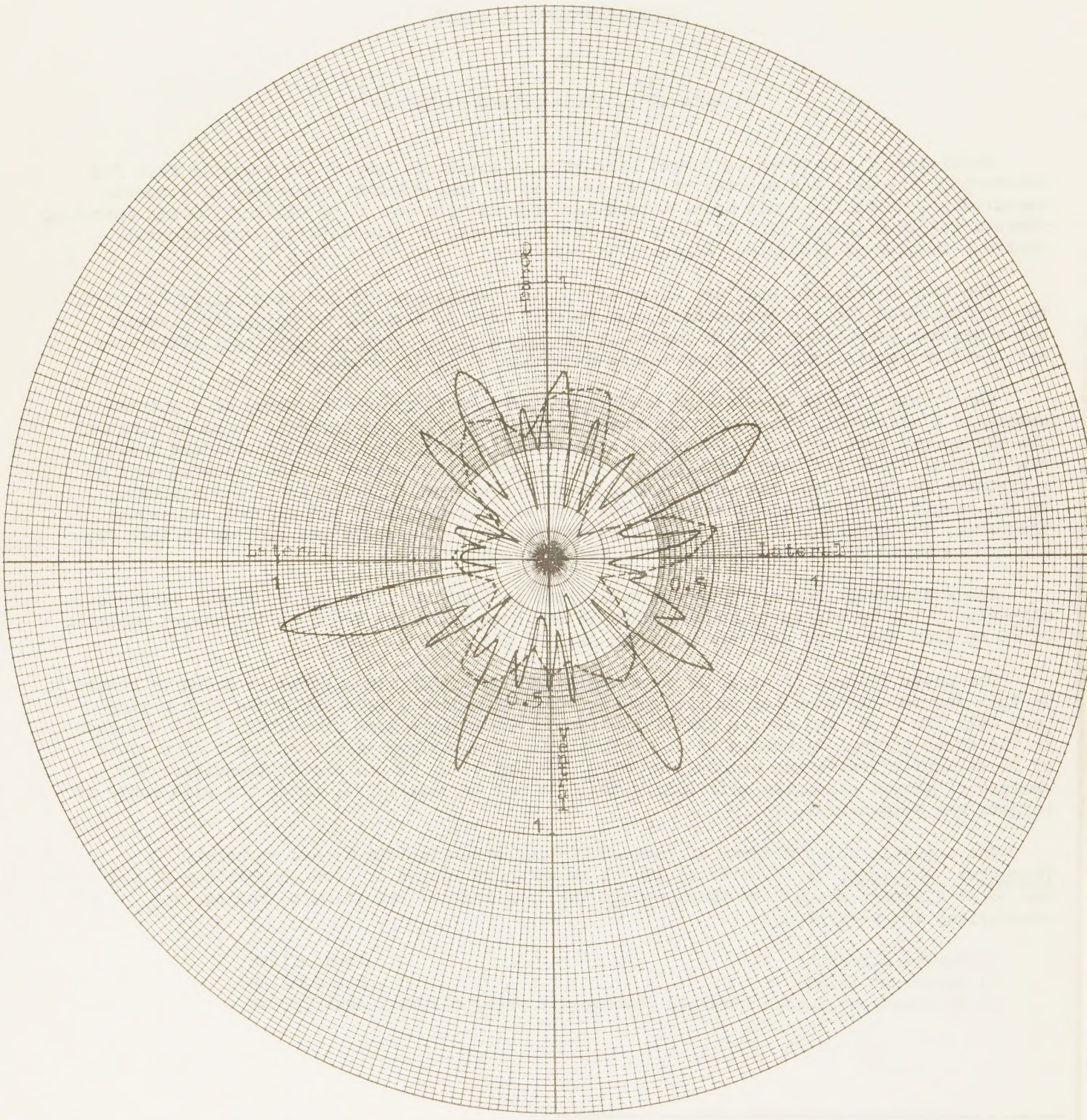


Figure 1. Polar diagrams of acoustic back-scattering from a squid, Doryteuthis bleekeri, at 50 kHz (dotted line) and 200 kHz (continuous line) around the long axis of squid. Mantle length: 12.9 cm; body weight: 112.7 g; water temperature: 21.5°C

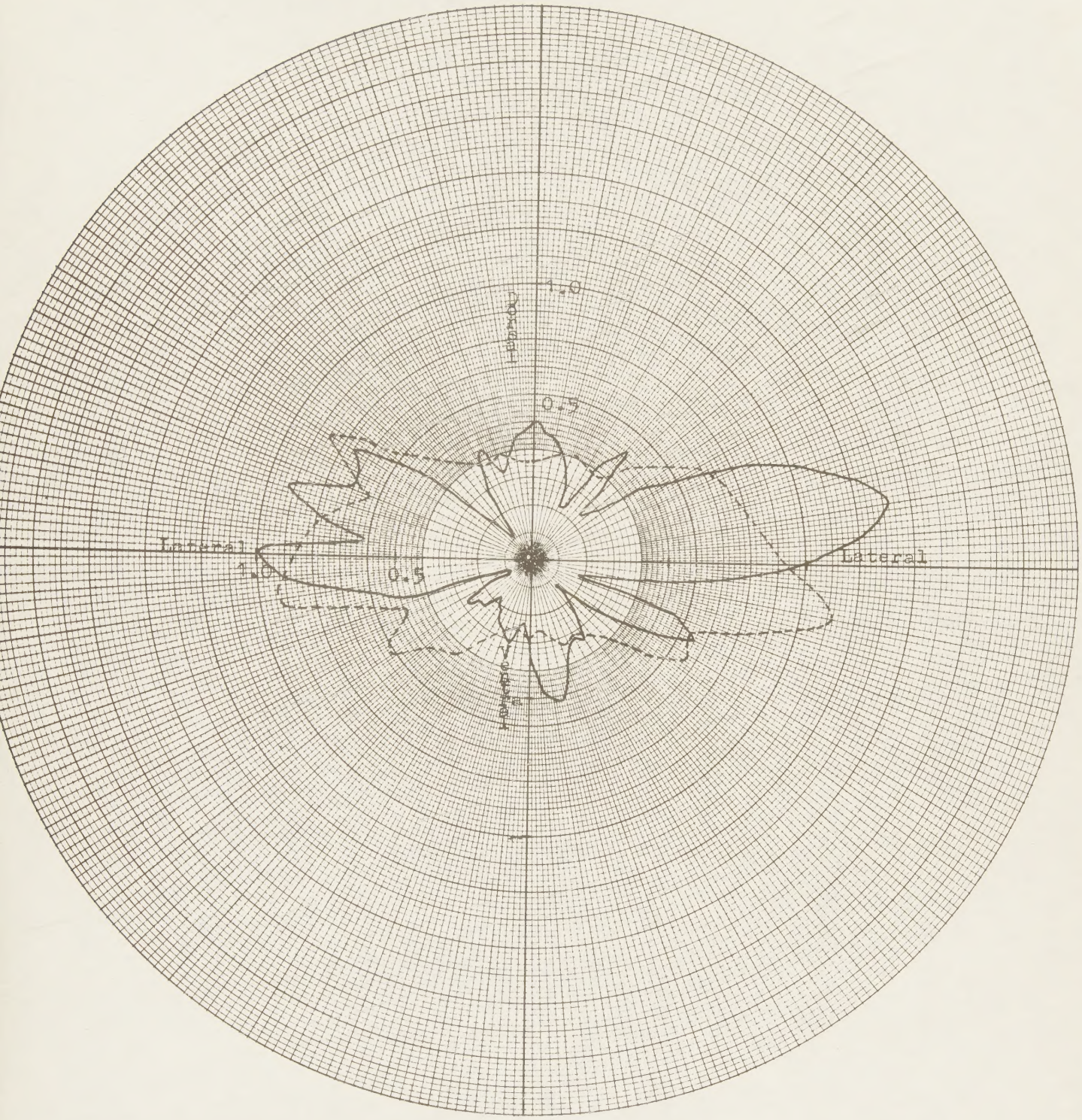


Figure 2. Acoustic polar diagrams from a jack mackerel, at 50 kHz (dotted line) and 200 kHz (continuous line) in roll plane. Fish total length: 13.0 cm; standard length: 11.2 cm; body depth: 1.5 cm; body width: 1.5 cm; weight: 19.4 g; water temperature: 21.8°C